SRT Evaluation of AIRS Version-6.02 Products

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AIRS Science Team Meeting

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Major Advances in Version-6 Compared to Version-5

- Improved methodology to determine skin temperature (T_s) and spectral emissivity (ε_v)
- Use of Neural-net start-up state (Bill Blackwell)

  Allows for accurate retrievals under more difficult cloud conditions
- Improvements which decrease the spurious negative Version-5 trend in tropospheric temperatures (Eric Maddy)

  Reducing spurious T(p) trends reduces other spurious trends as well
- Improved QC methodology

  Separate QC thresholds for Data Assimilation (QC=0) and Climate applications (QC=0,1)
- Channel-by-channel clear-column radiance $\hat{R}_i$ QC flags
- Improved cloud parameter retrieval algorithm (Evan Manning, Van Dang, John Blaisdell)
- Improved OLR RTA (Gyula Molnar)

Evaluation Methodology

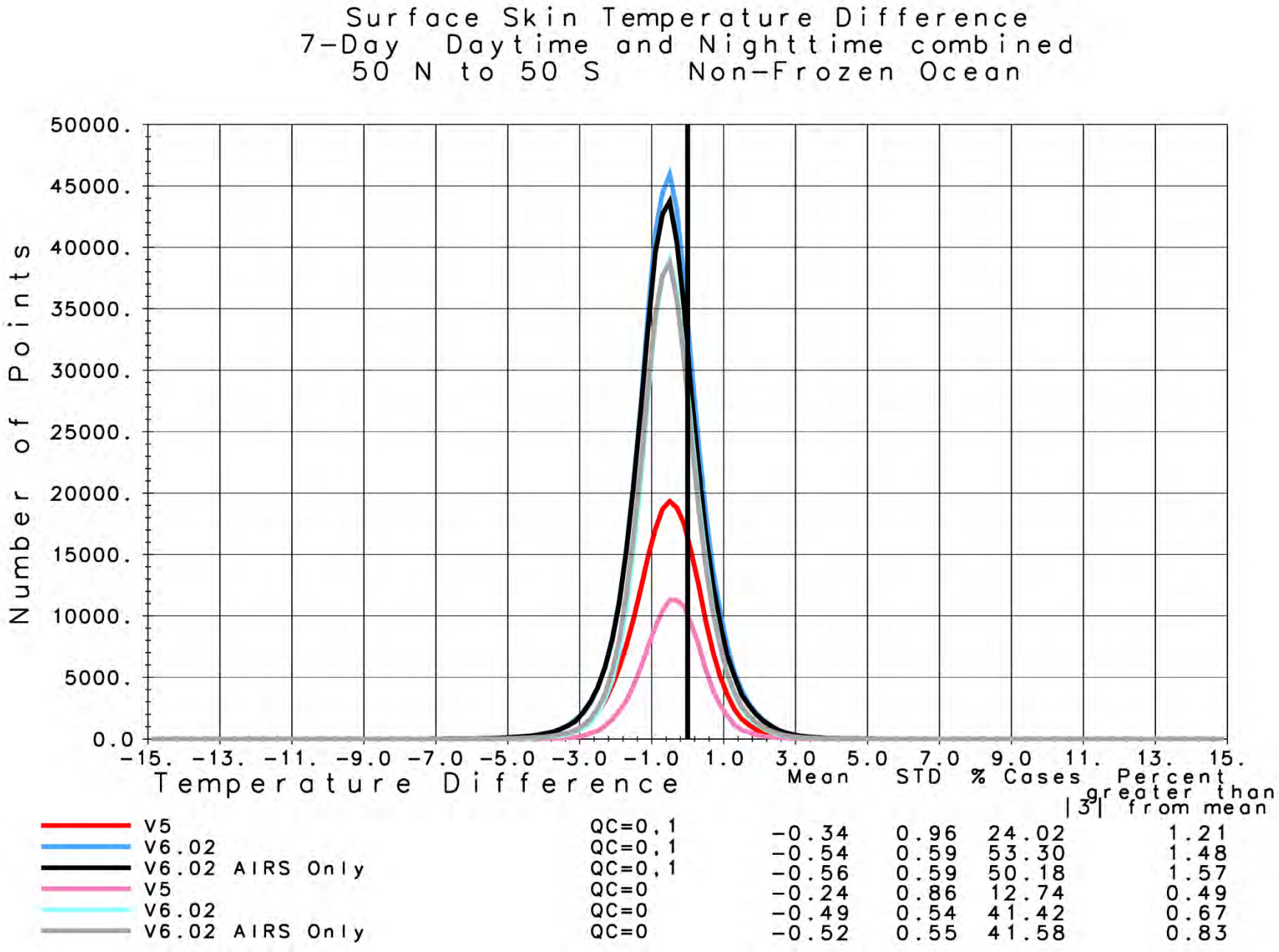
Comparisons of V6.02, V6.02 AO, and V5.0

Products to be evaluated

T_s, ε_v, T(p), q(p), OLR, OLR_{CLR}, α, $\hat{R}_i$

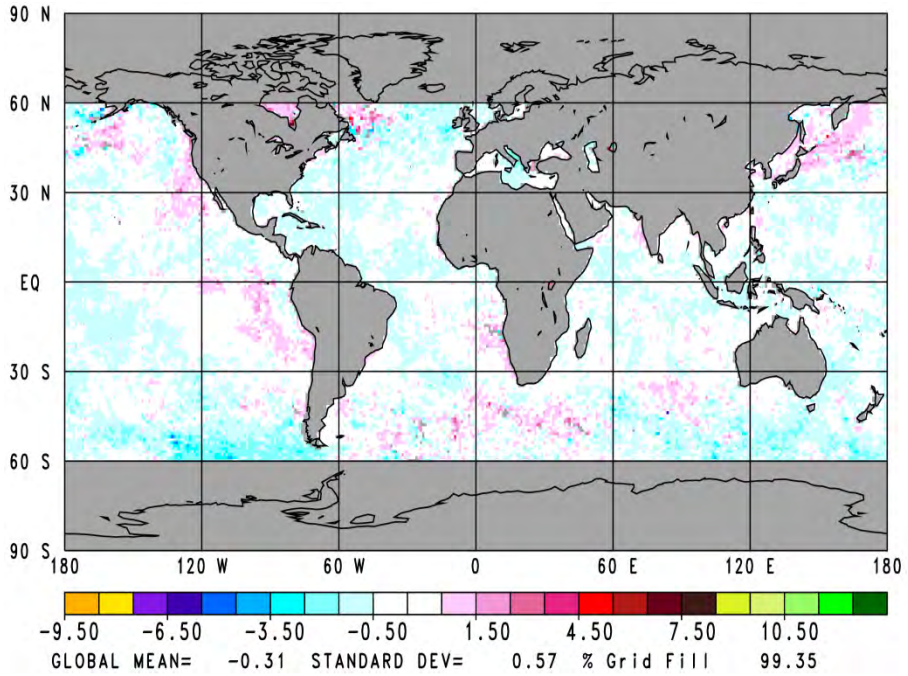
Two types of evaluation

- 7 focus days compared to ECMWF truth
  - T_s, ε_v, T(p), q(p)
    - RMS differences, yields, biases, trends
  - $\hat{R}_i$ channel by channel QC'd values for V6.02 and V6.02 AO
    - yields, accuracy
- Monthly means for 4 different months, 3 different years
  - V6.02(actually V5.9.12) compared to V5.0
    - T(p), q(p), α, OLR, OLR_{CLR}
      - trends, trend differences

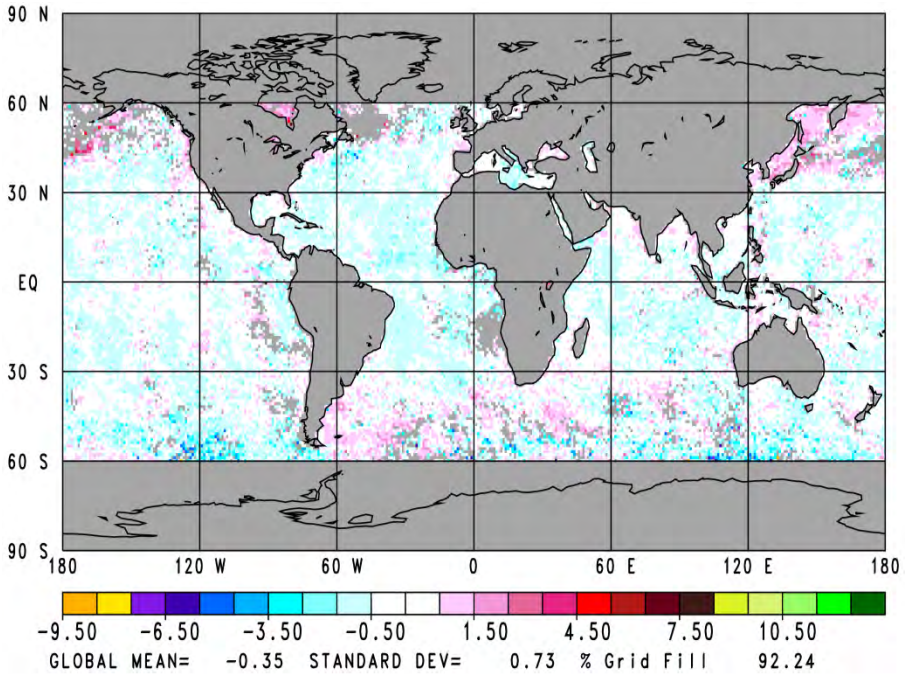

Surface Skin Temperature Difference
7-Day Daytime and Nighttime combined
50 N to 50 S Non-Frozen Ocean
Number of Points
50000.
45000.
40000.
35000.
30000.
25000.
20000.
15000.
10000.
5000.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent
greater than
|3| from mean
V5 QC=0,1 -0.34 0.96 24.02 1.21
V6.02 QC=0,1 -0.54 0.59 53.30 1.48
V6.02 AIRS Only QC=0,1 -0.56 0.59 50.18 1.57
V5 QC=0 -0.24 0.86 12.74 0.49
V6.02 QC=0 -0.49 0.54 41.42 0.67
V6.02 AIRS Only QC=0 -0.52 0.55 41.58 0.83

7-Day Surface Skin Temperature (K) Non-Frozen Ocean
Retrieved minus ECMWF AM/PM Average

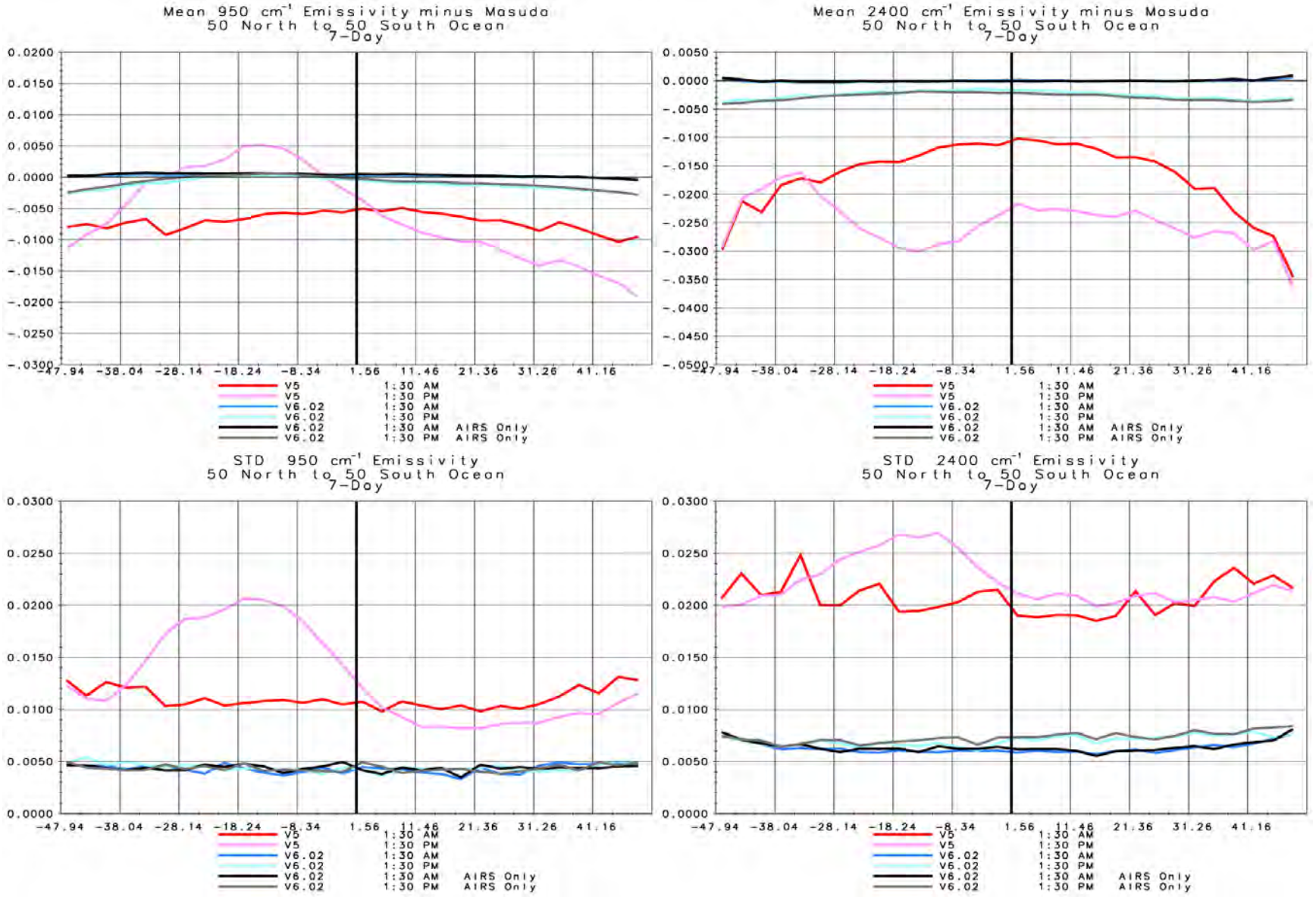
Version-6.02



Version-5



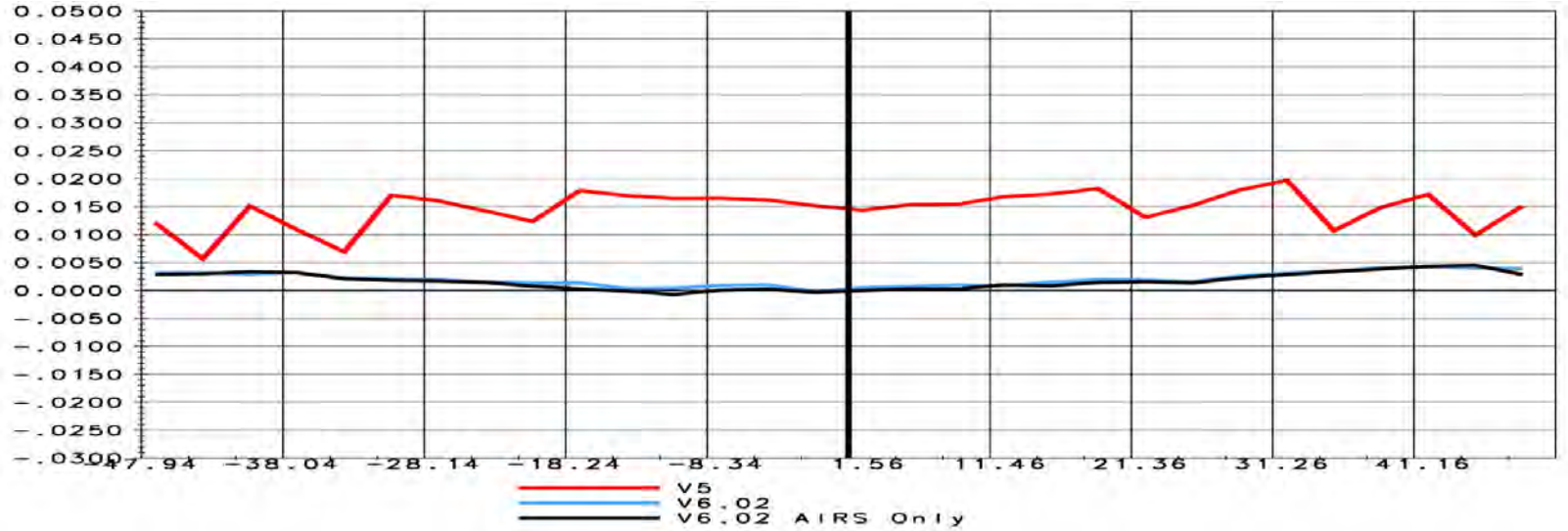
Seven day Version-6 Level-3 SST product has much better spatial coverage and accuracy compared to Version-5 Level-3 SST product.



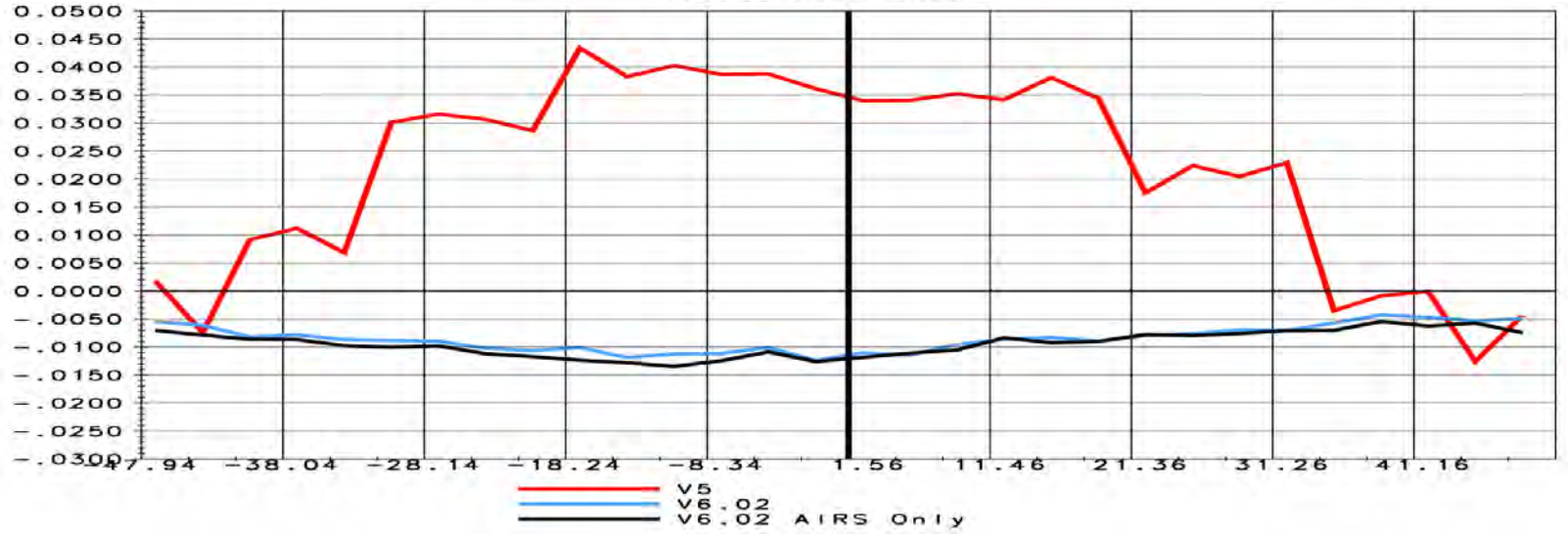
AIRS Version-6 ocean spectral emissivities as a function of satellite zenith angle are much closer to Masuda than Version-5 and are more stable.

Mean AM minus PM Emissivity 7-Day Average
50° North to 50° South Land

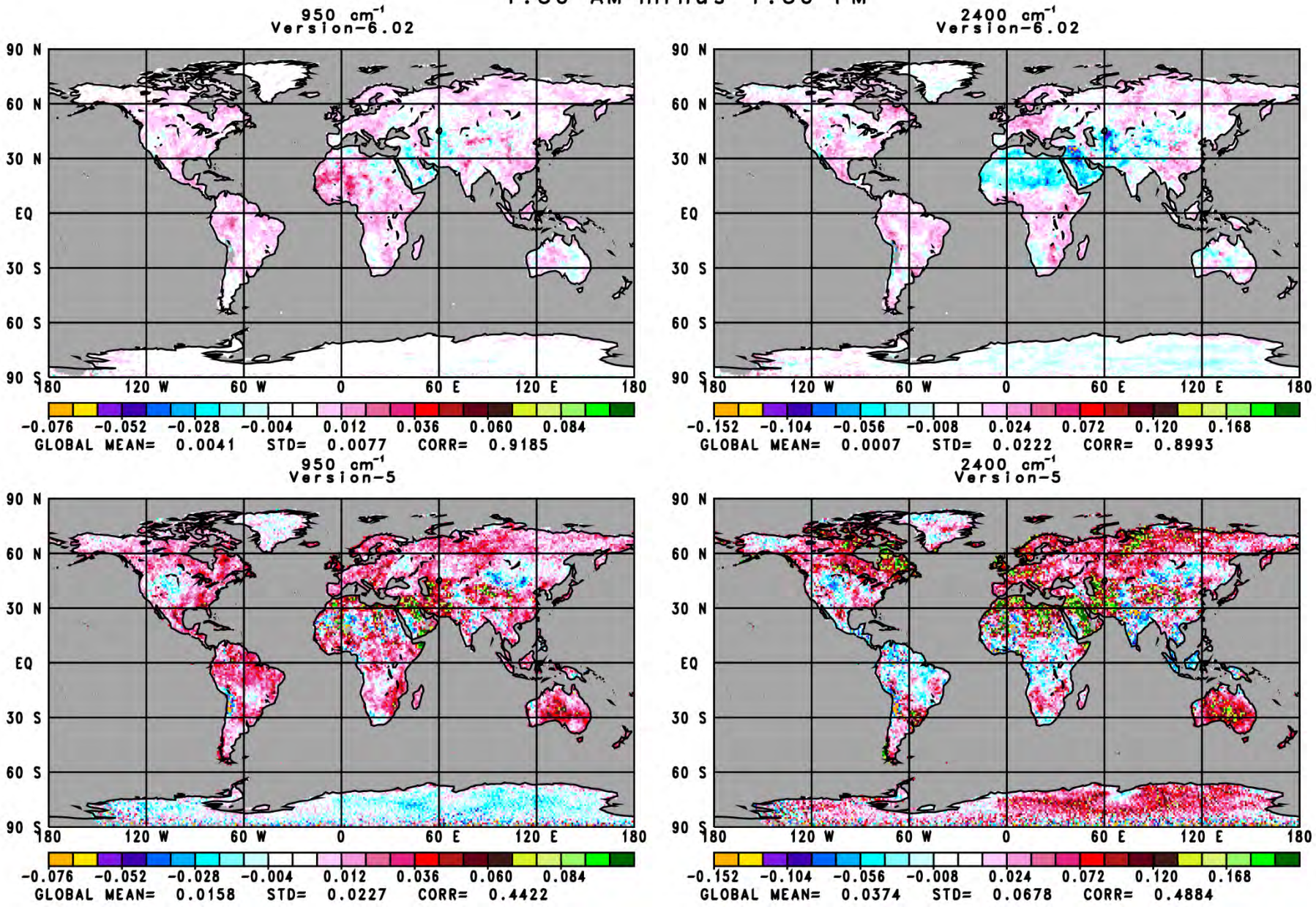
950 cm^{-1}



2400 cm^{-1}

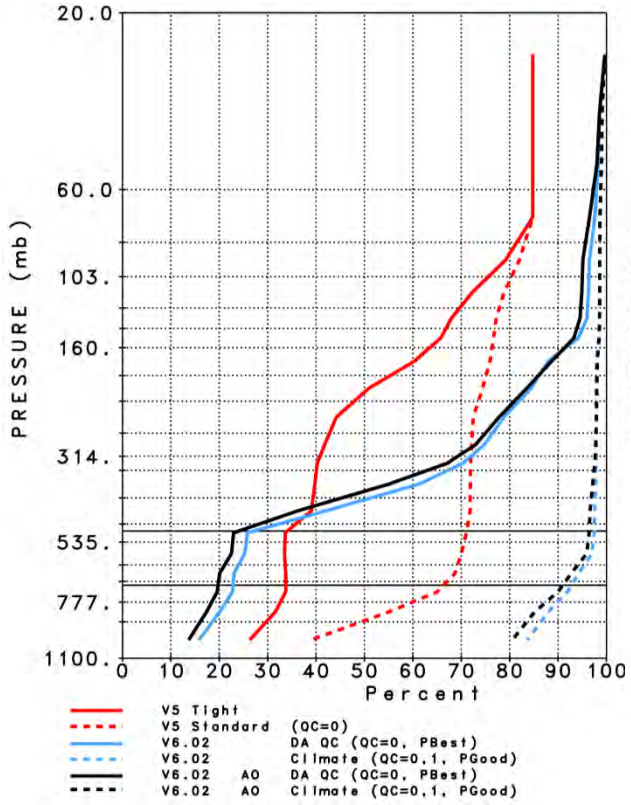


AIRS Version-6 day/night differences of land surface emissivity as a function of zenith angle and much smaller than Version-5.

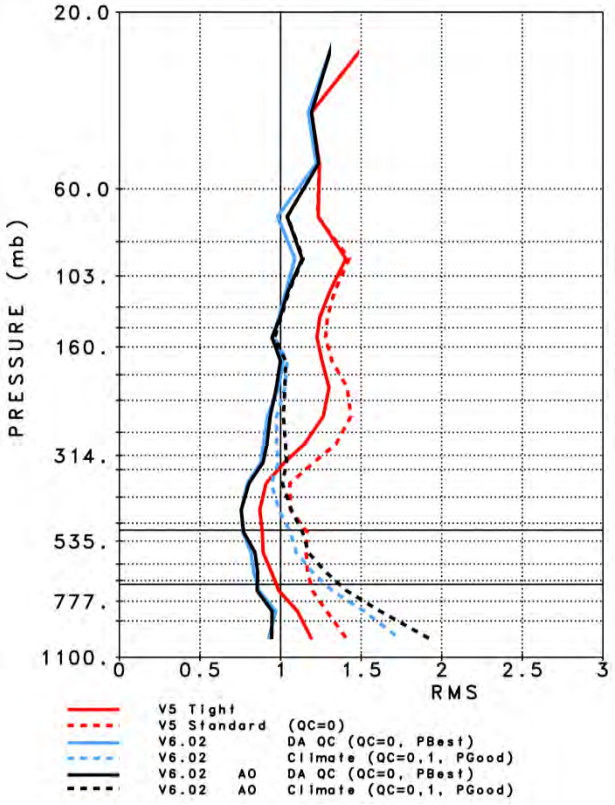

7-Day
AIRS IR Emissivity
1:30 AM minus 1:30 PM
950 cm-1
Version-6.02
2400 cm-1
Version-6.02
950 cm-1
Version-5
2400 cm-1
Version-5
90 N
60 N
30 N
EQ
30 S
60 S
90 S
180
120 W
60 W
0
60 E
120 E
180
-0.076 -0.052 -0.028 -0.004 0.012 0.036 0.060 0.084
GLOBAL MEAN= 0.0041 STD= 0.0077 CORR= 0.9185
-0.152 -0.104 -0.056 -0.008 0.024 0.072 0.120 0.168
GLOBAL MEAN= 0.0007 STD= 0.0222 CORR= 0.8993
-0.076 -0.052 -0.028 -0.004 0.012 0.036 0.060 0.084
GLOBAL MEAN= 0.0158 STD= 0.0227 CORR= 0.4422
-0.152 -0.104 -0.056 -0.008 0.024 0.072 0.120 0.168
GLOBAL MEAN= 0.0374 STD= 0.0678 CORR= 0.4884

Global Temperature 7-Day Statistics use their own QC

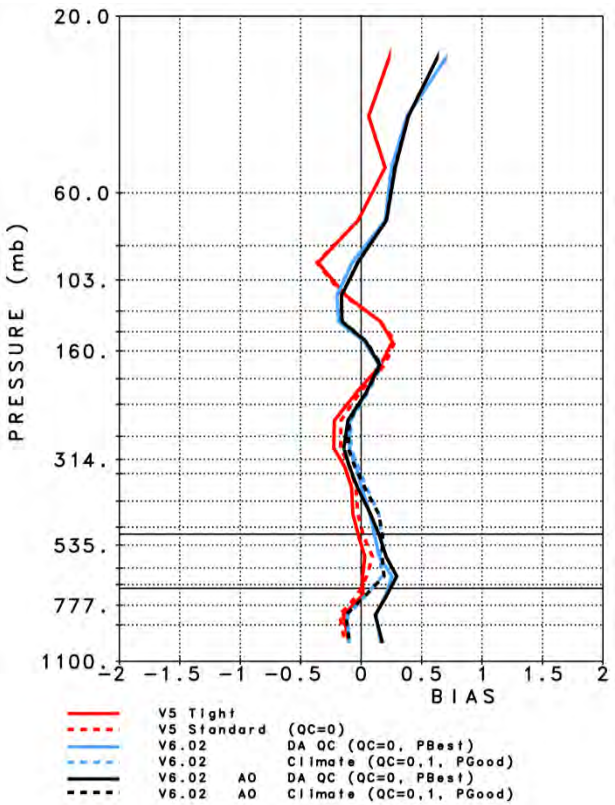
Percent of All Cases Accepted



Layer Mean RMS (°K) Differences from ECMWF



Layer Mean BIAS (°K) Differences from ECMWF



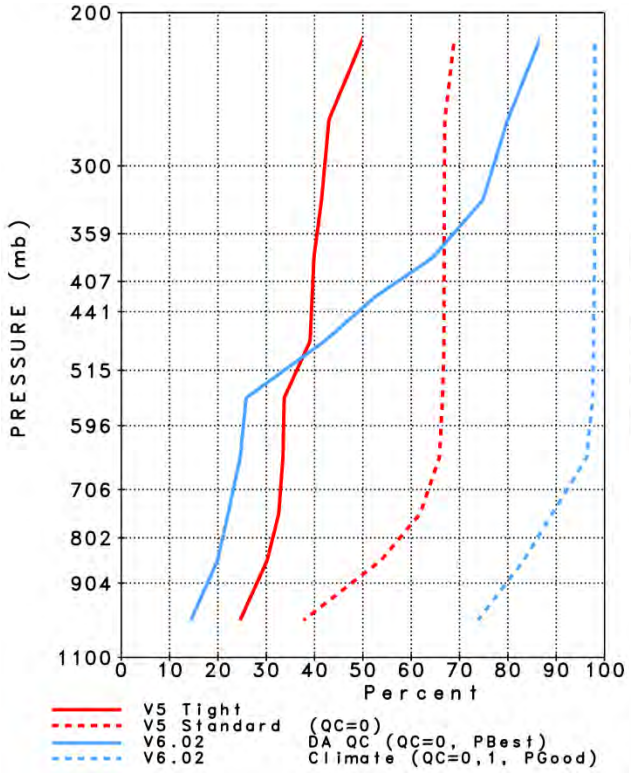
Version-6 T(p) retrievals with DA QC have RMS errors ≤ 1K throughout troposphere

Version-6 T(p) retrievals with Climate QC have much greater yield than Verison-5 with small biases

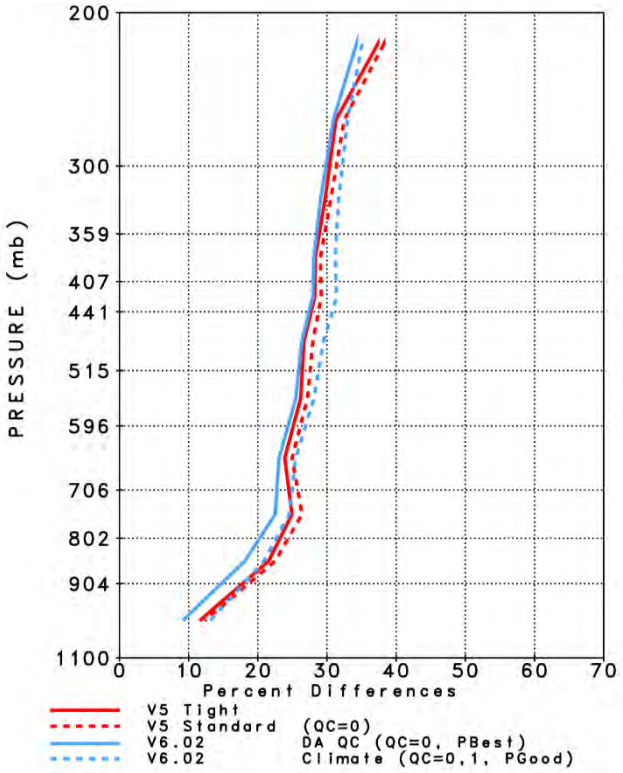
Differences between Version-6.02 and Version-6.02 AO are small

Global Water Vapor 7-Day Statistics use their own QC

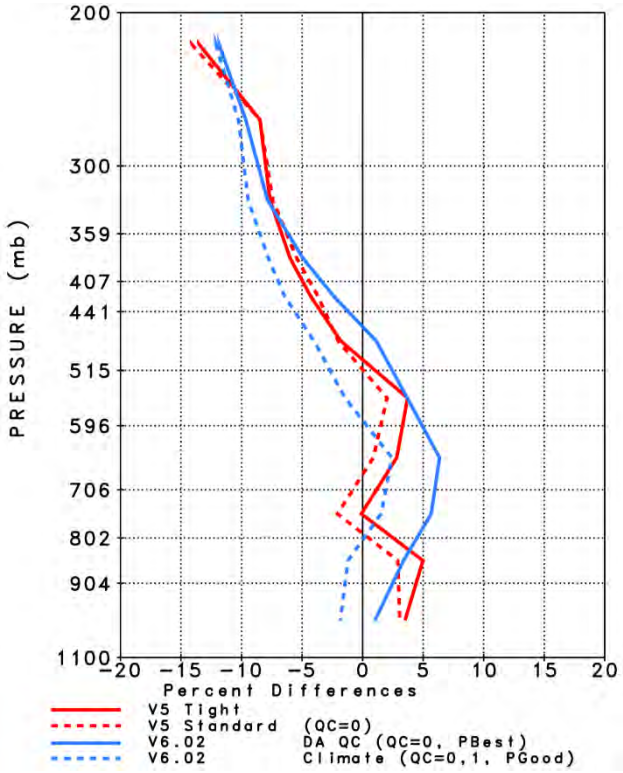
Percent Yield



1 Km Layer Mean Precipitable Water RMS % Differences from ECMWF



1 Km Layer Mean Precipitable Water Bias % Differences from ECMWF



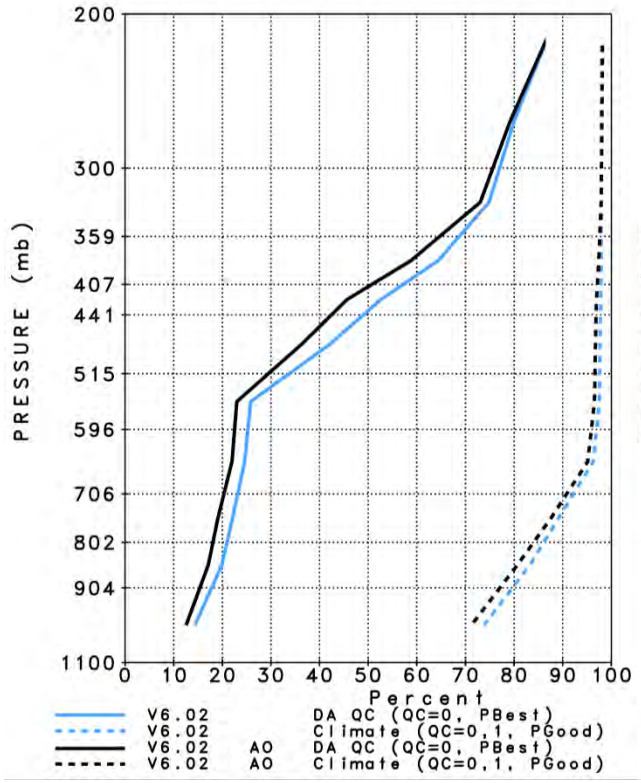
Version-6 q(p) retrievals with DA QC are improved over Version-5 in lower troposphere

This is a result of improved T_s, ε_v

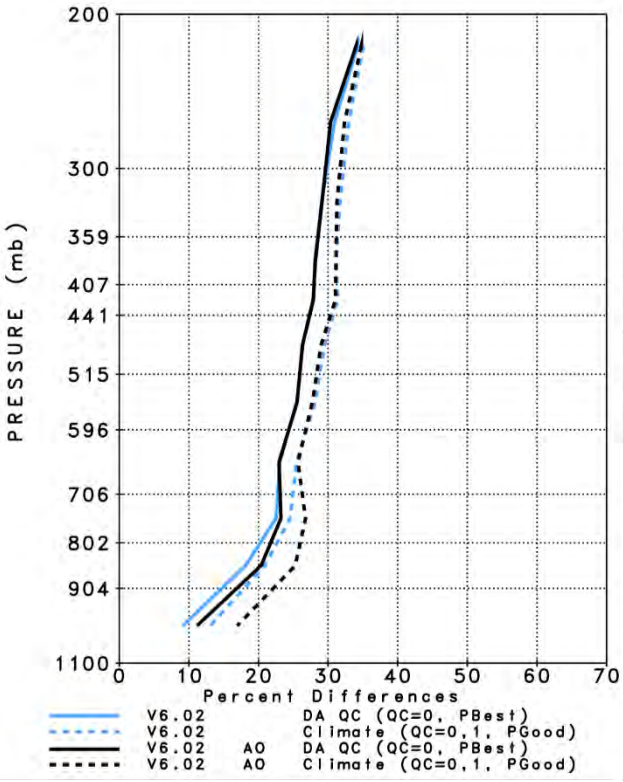
Version-6 q(p) retrievals with Climate QC are unbiased and have high accuracy with almost complete spatial coverage

Global Water Vapor 7-Day Statistics use their own QC

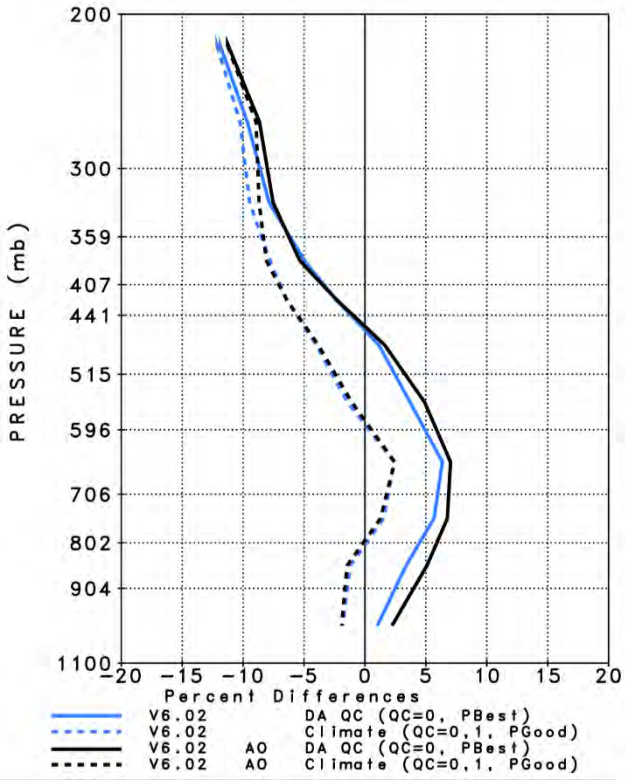
Percent Yield



1 Km Layer Mean
Precipitable Water RMS
% Differences from ECMWF



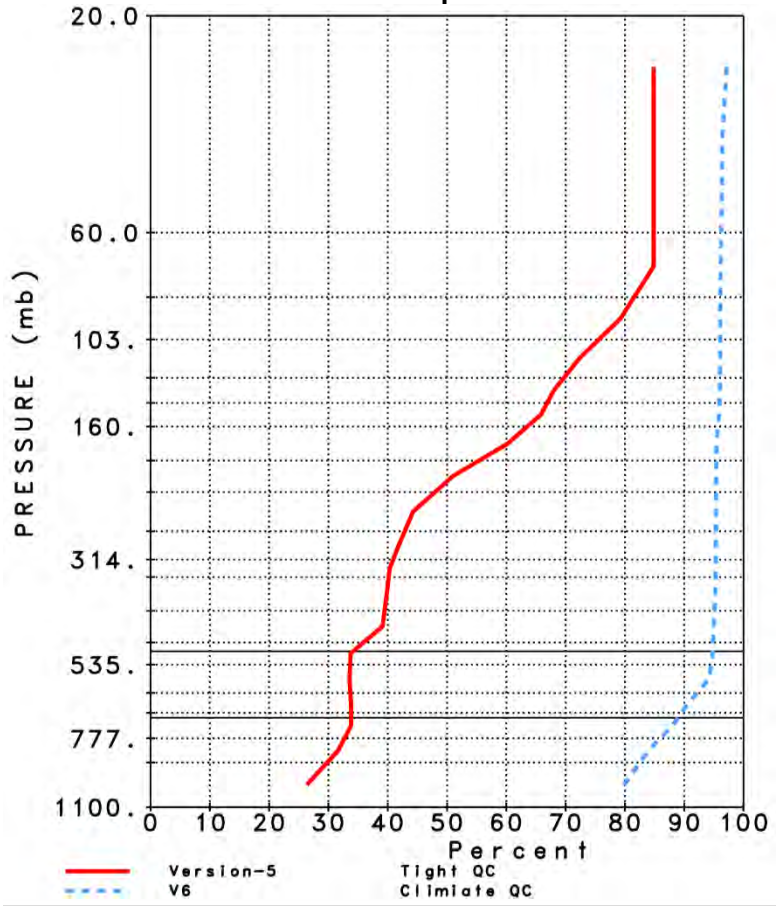
1 Km Layer Mean
Precipitable Water Bias
% Differences from ECMWF



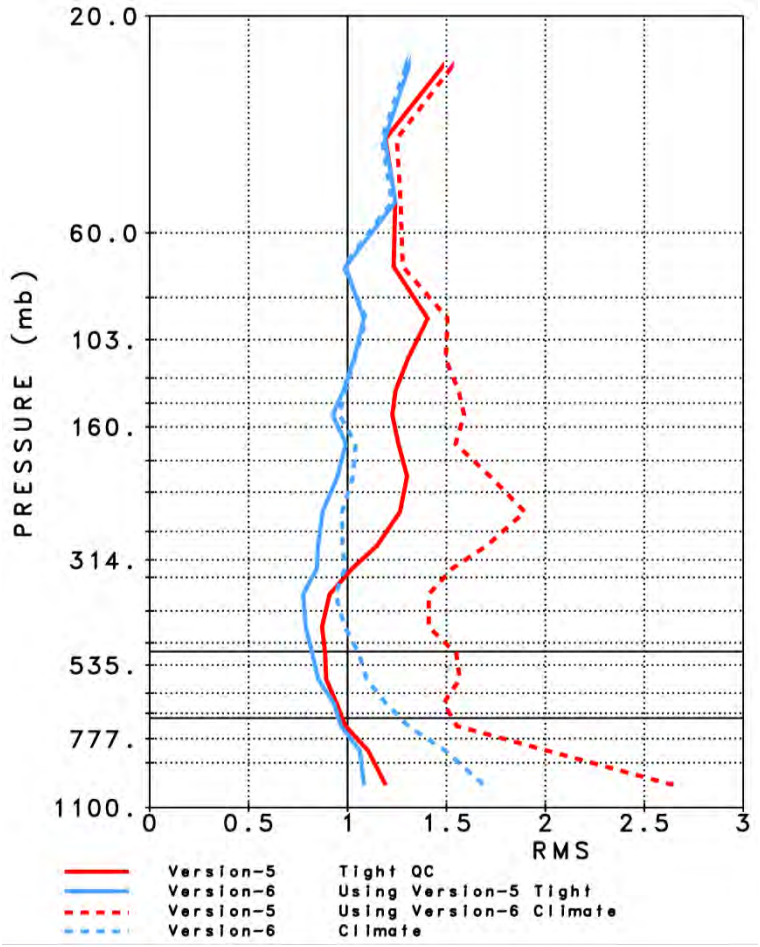
Version-6 AO water vapor retrievals are slightly poorer than Version-6, but still of high accuracy.

Global Temperature 7-Day
Two Common Ensembles

Percent of All Cases Accepted



Layer Mean RMS (°K) Differences from ECMWF



7-Day Mean Statistics Tropospheric Temperature Metric (TTM) and Boundary Layer Metric (BLM)

Cases in Common Using the Version-5 Tight Ensemble

	Global		Land ±50˚		Ocean ±50˚		Poleward of 50˚N		Poleward of 50˚S	
	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM
Version-5	1.10	1.29	1.19	1.71	1.04	1.13	1.14	1.50	1.31	1.76
Version-6.02	0.92	1.16	0.94	1.49	0.86	0.98	0.96	1.47	1.20	1.69

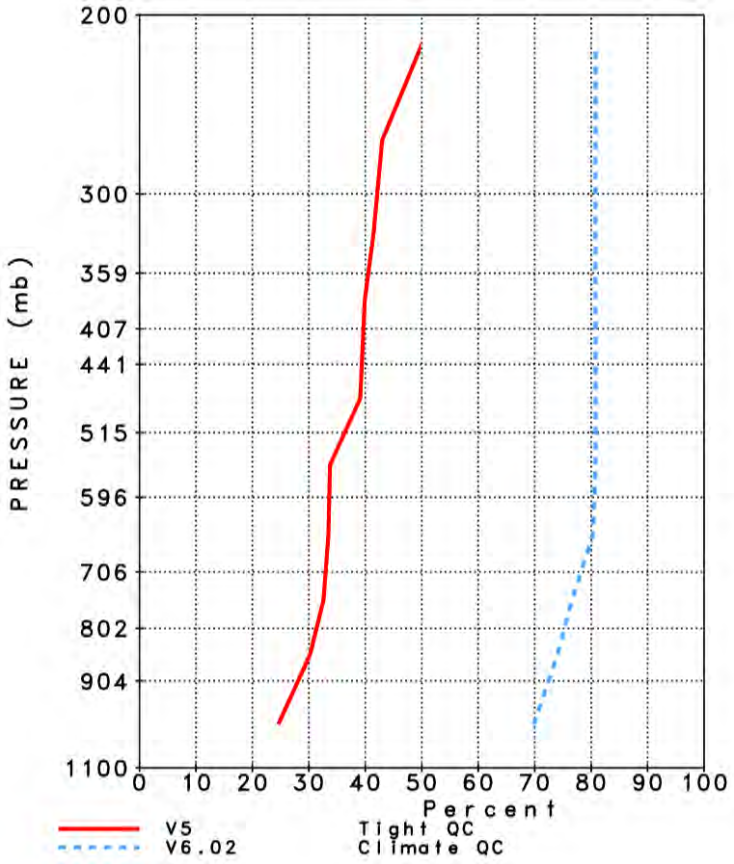
Cases in Common Using the Version-6.02 Climate Ensemble

	Global		Land ±50˚		Ocean ±50˚		Poleward of 50˚N		Poleward of 50˚S	
	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM
Version-5	1.67	2.57	1.82	2.78	1.65	2.48	1.53	2.39	1.72	2.72
Version-6.02	1.11	1.67	1.06	1.75	1.03	1.34	1.12	1.93	1.32	2.02

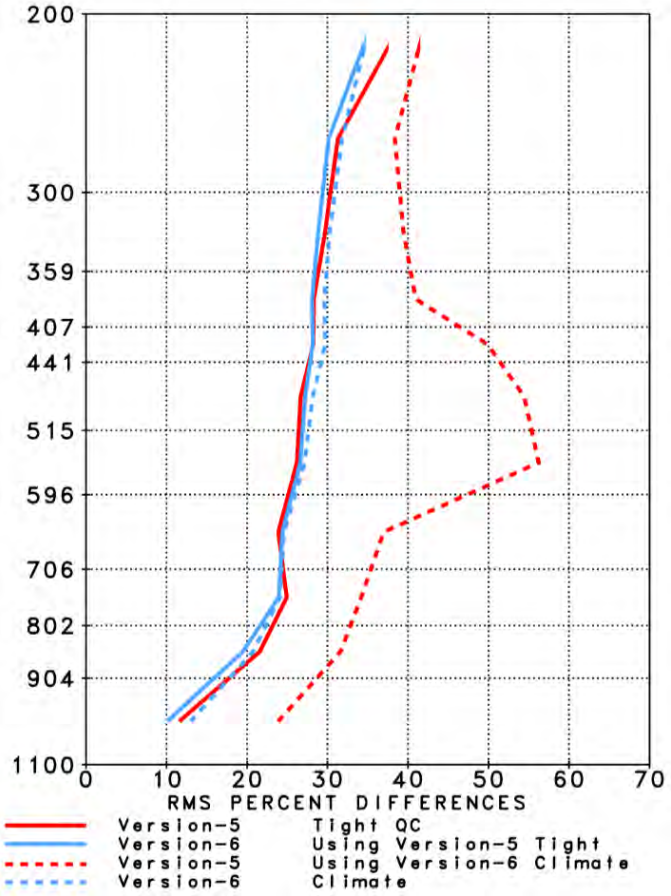
TTM represents the mean RMS T(p) error over all 1km layers from the surface to 100 mb
BLM represents the mean RMS T(p) error over the 6 lowest 0.25km layers from the surface

Global Water Vapor 7-Day Statistics using a Common Ensemble

Percent Yield



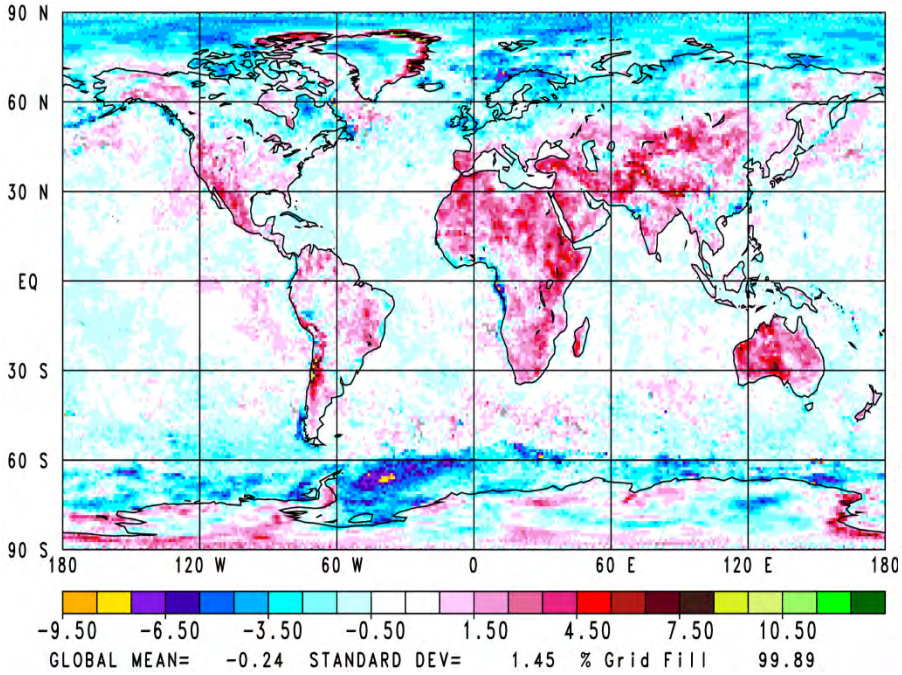
1 Km Layer Mean
Precipitable Water RMS
% Differences from ECMWF



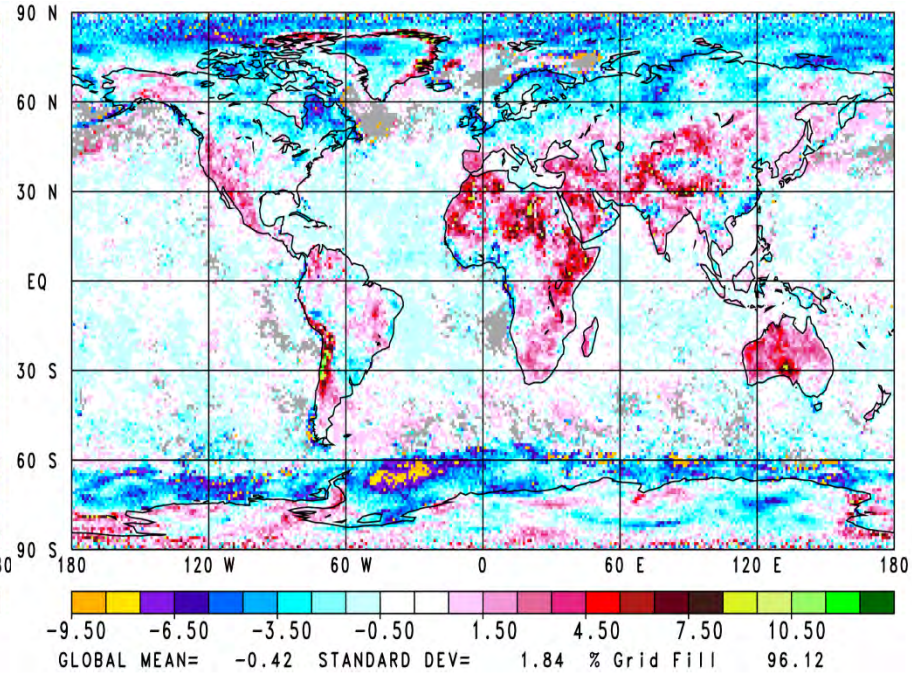
High accuracy of Version-6 water vapor products under most cloud conditions allows for much better level-3 water vapor products.

7-Day Surface Total Precipitable Water (cm)
Retrieved minus ECMWF AM/PM Average

Version-6.02

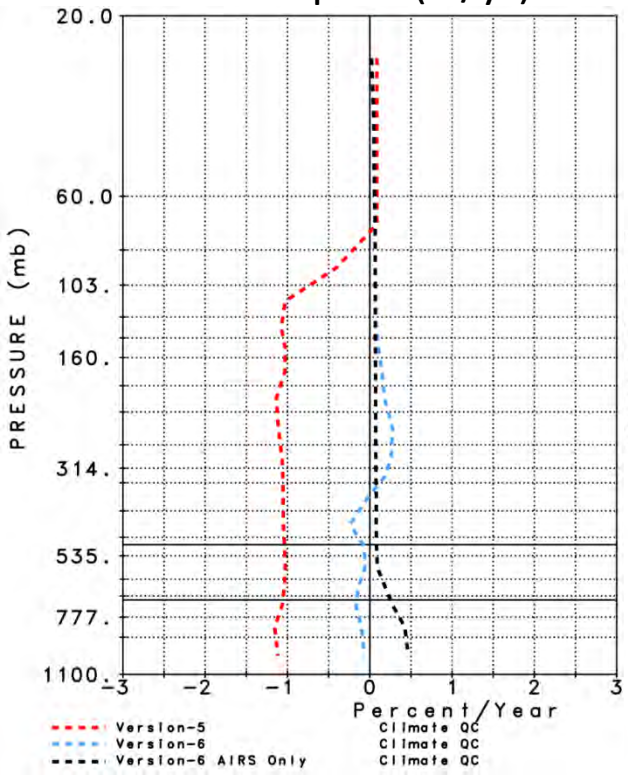


Version-5

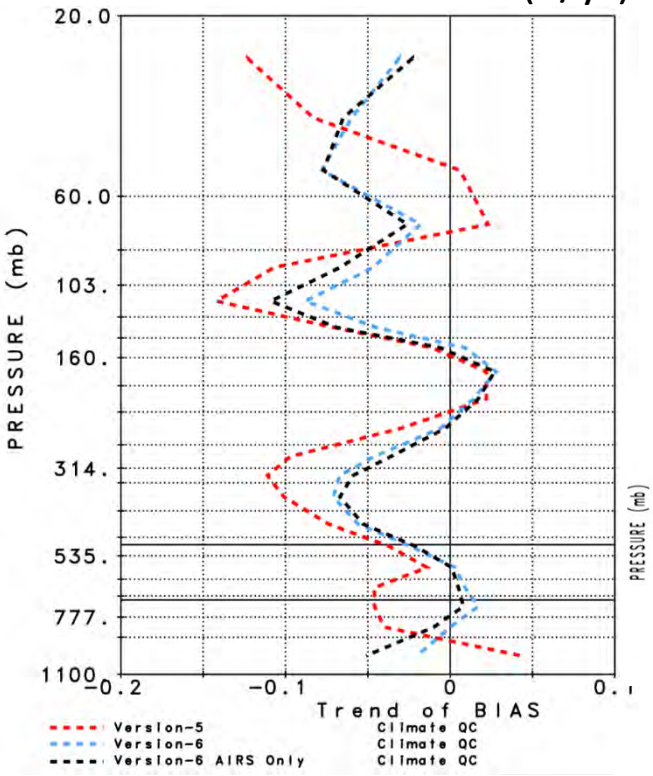


Global Trends 7-Day

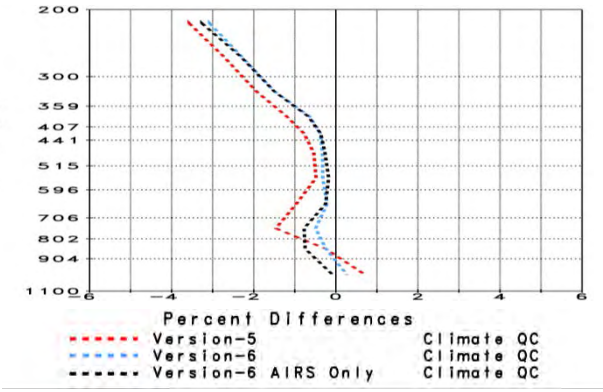
Percent of All Cases Accepted (%/yr)



Layer Mean Temperature BIAS Differences from ECMWF (K/yr)



Layer Mean Water Vapor Bias % Differences from ECMWF (%/yr)



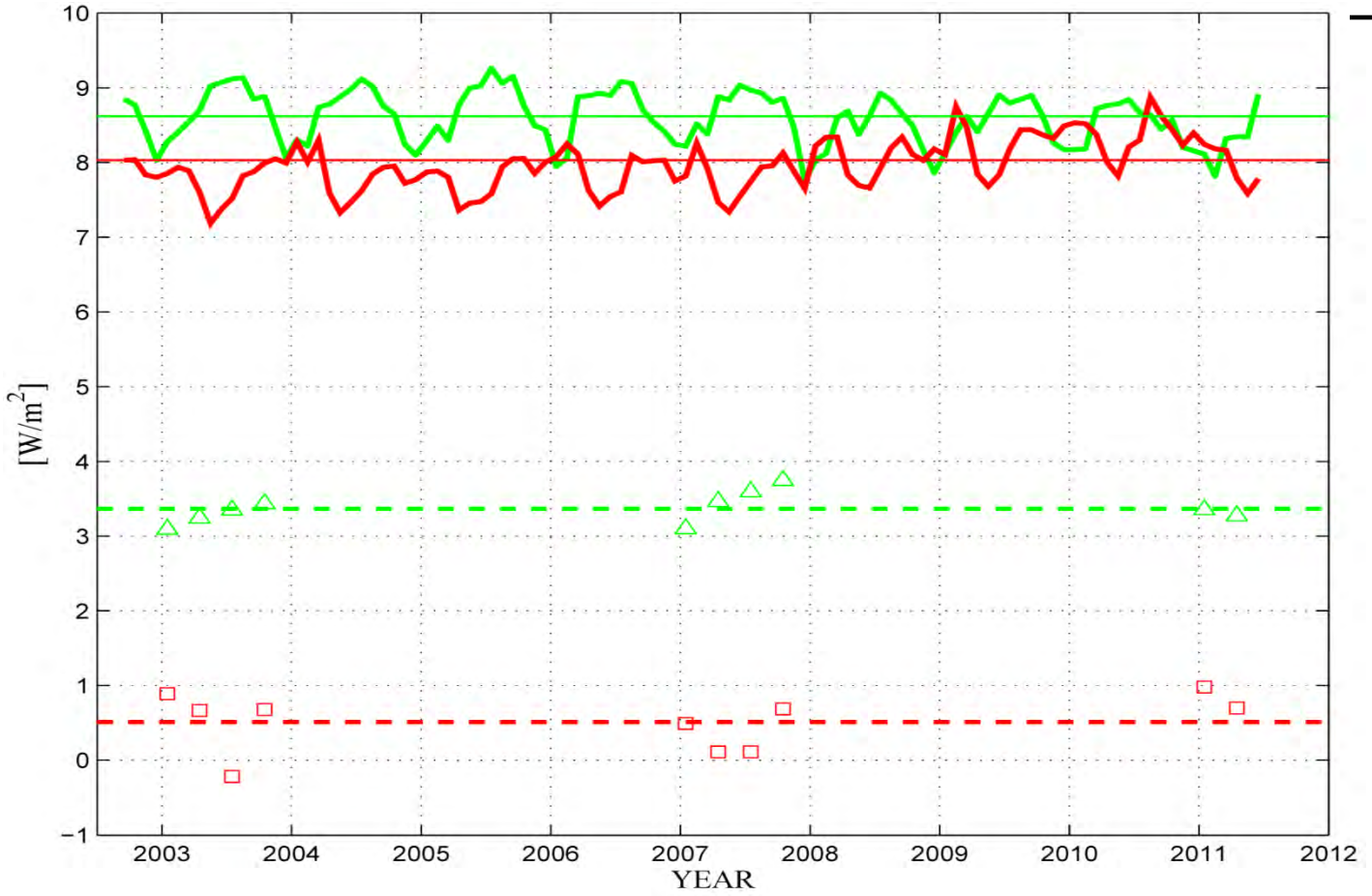
Version-6 has eliminated the negative yield trend found in Version-5

Version-6 negative T(p) and q(p) bias trends are much smaller than Version-5

Negative q(p) bias trends follow those of T(p)

- A cold temperature solution (trend) result lowers computed radiance for water vapor channels
- The q(p) solution will decrease the retrieved water amount to raise the computed radiances
- Lowered q(p) (trend) gives too high a computed radiance in window channels – results in increased retrieved cloud fraction (trend)

Global OLR and Clear Sky OLR
AIRS minus CERES Edition 2.6r EBAF
September 2002 through June 2011



AIRS Version-5 minus CERES OLR

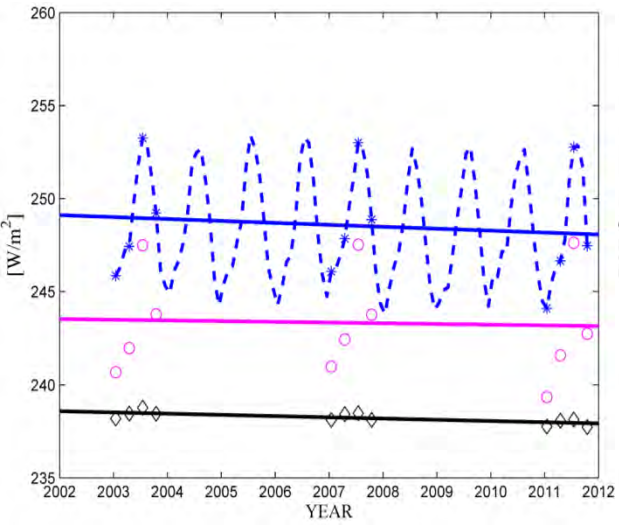
△ AIRS Version-5.9.12 minus CERES OLR

AIRS Version-5 minus CERES Clear Sky OLR

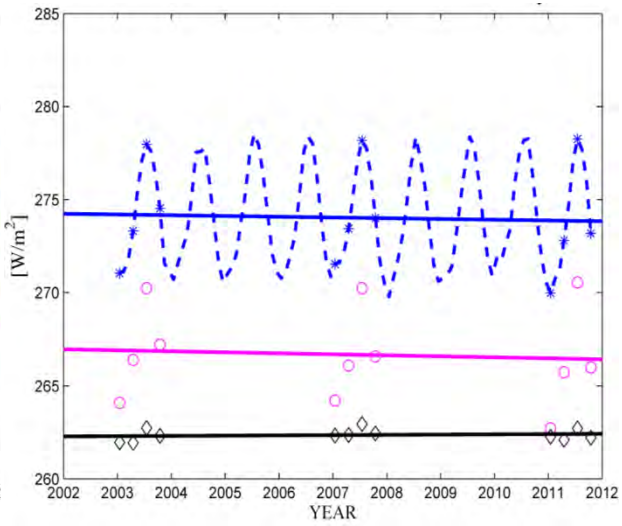
□ AIRS Version-5.9.12 minus CERES Clear Sky OLR

Global Time Series January 2003 through October 2011

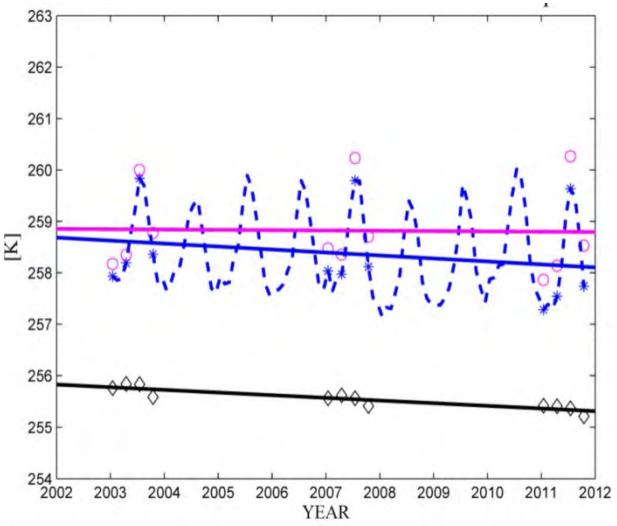
OLR (W/m^2)



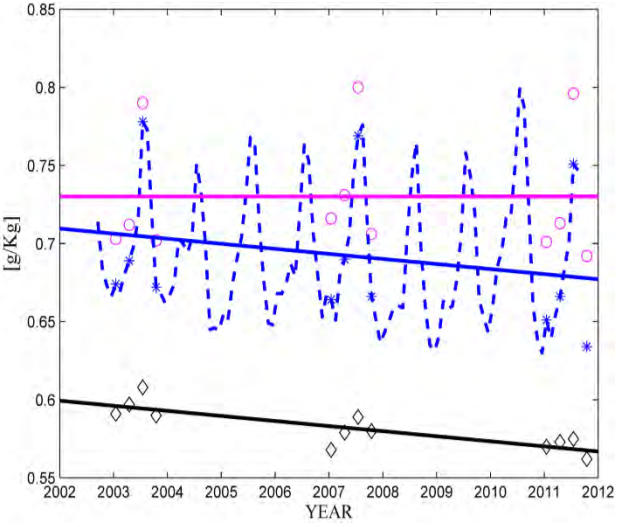
Clear Sky OLR (W/m^2)



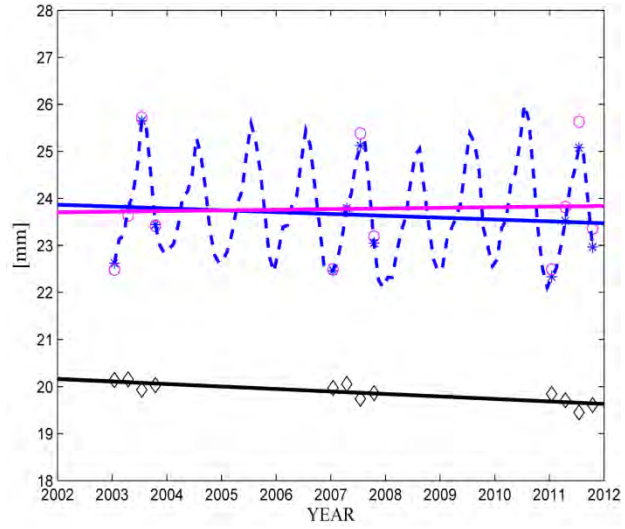
500 mb Temperature (K)



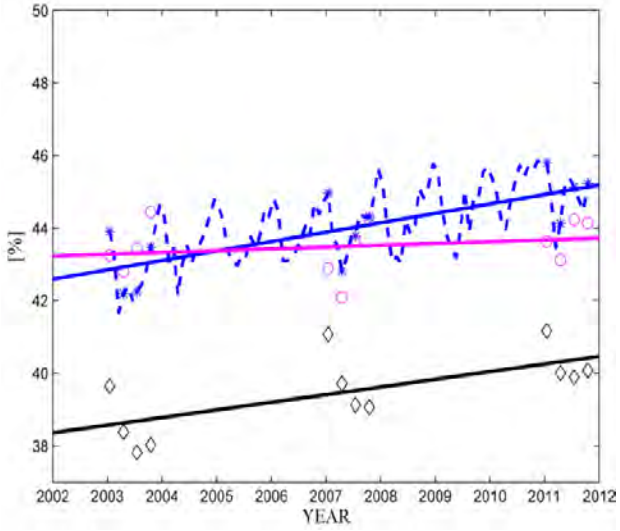
500 mb Mixing Ratio (g/Kg)



Total Precipitable Water (mm)



Effective Cloud Fraction (%)



AIRS V5 January 2003 through October 2011

AIRS V5 12 Months

AIRS V5.9.12 12 Months

AIRS V5 minus AIRS v5.9.12

Slope

Slope

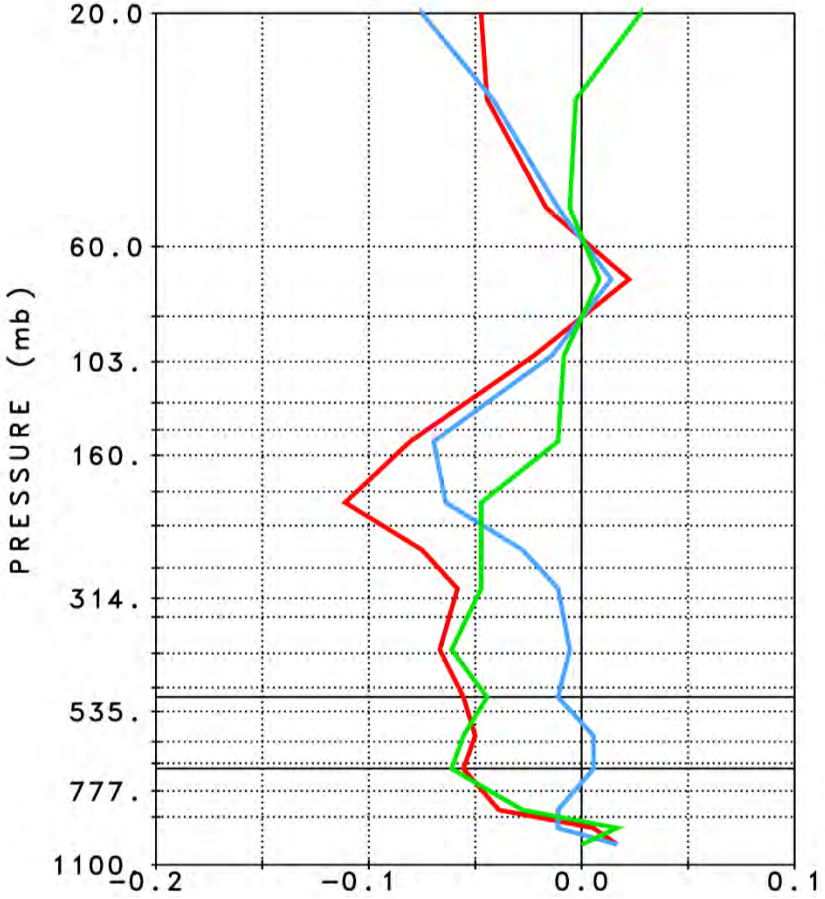
12 Month Global Time Series Slopes (Trends)
January 2003 through October 2011

	OLR $W/m^2/yr$	Clear Sky OLR $W/m^2/yr$	500 mb Temp K/yr	500 mb Mixing Ratio g/Kg/yr	Total Precipitable Water mm/yr	Cloud Fraction %/yr
✳ AIRS V5	-0.104	-0.040	-0.058	-0.00325	-0.392	0.260
○ AIRS V5.9.12	-0.038	-0.054	-0.006	0.00001	0.137	0.049
◇ AIRS V5 minus AIRS v5.9.12	-0.066	0.014	-0.052	-0.00326	-0.529	0.211

Computed V5 and V5.9.12 product trends can be misleading because whole annual cycle is not captured

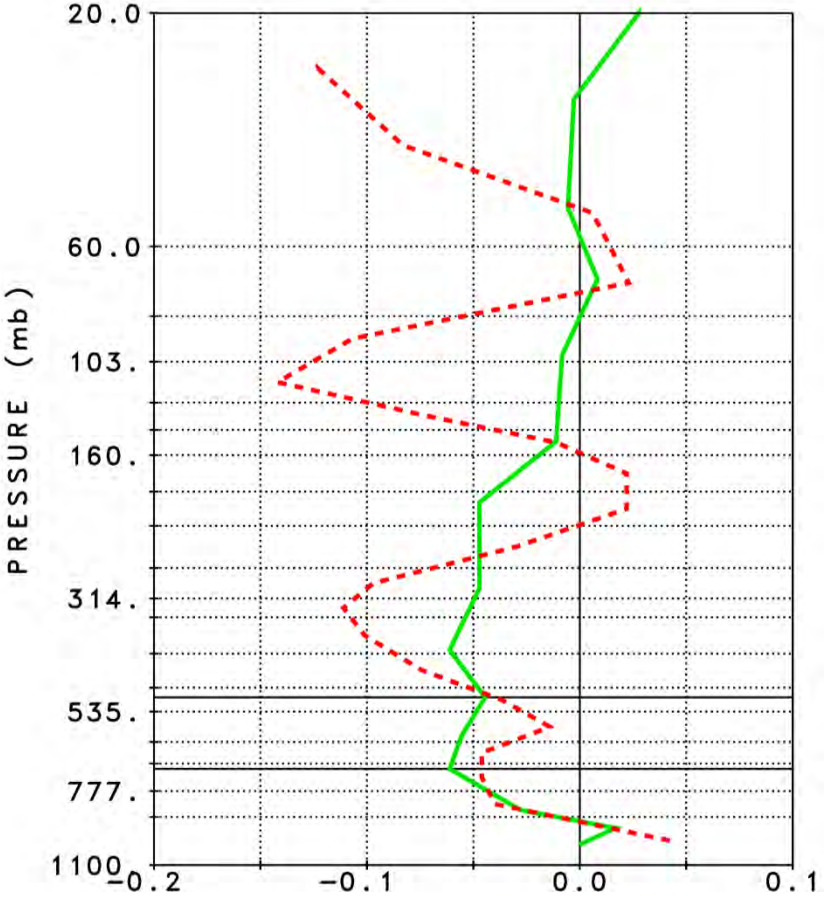
The trend difference V5 minus V5.9.12 is much more significant

Global Temperature Trends K/Yr
12 Monthly, January 2003 through October 2011



Version-5
Version-6
Version-5 minus Version-6

Global Temperature Trends K/Yr

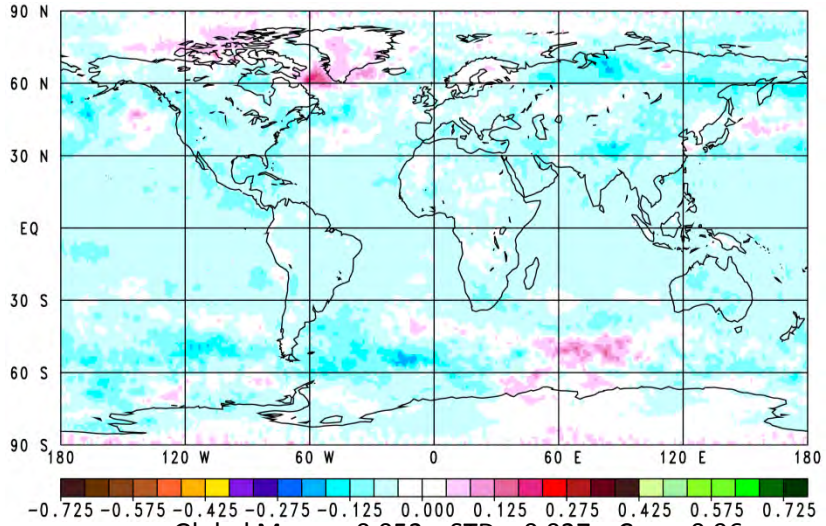


Version-5 minus Version-6 12 Months
Version-5 minus ECMWF 7-Day

Version-6 should minimize spurious negative T(p) trend found in Version-5 beneath 200 mb

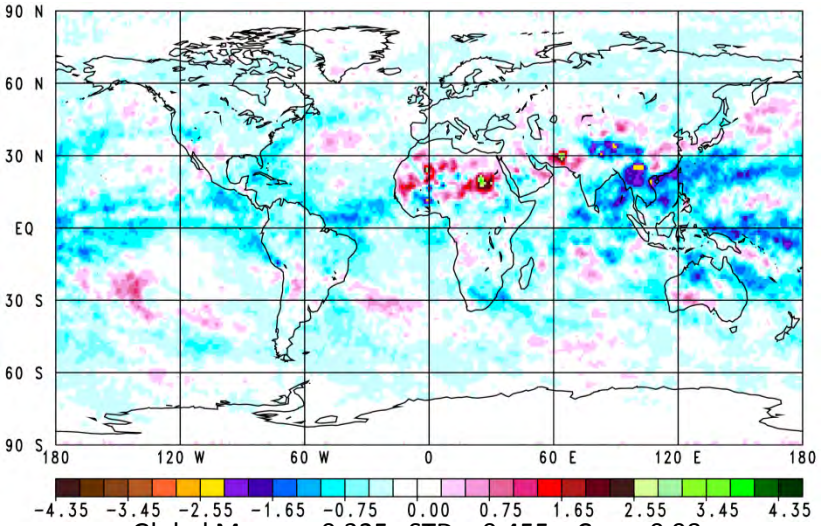
12 Month Trend Differences
Version-5 minus Version-6

500 mb Temperature (K/yr)



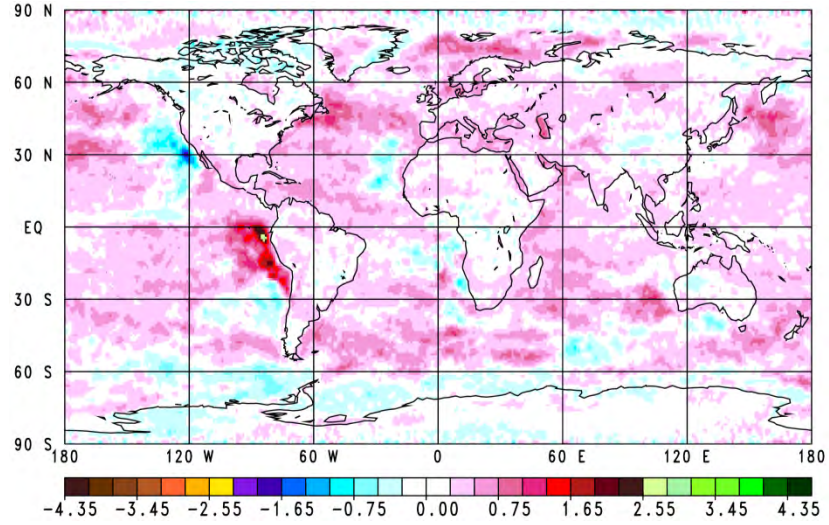
Global Mean= -0.052 STD= 0.027 Corr= 0.96

500 mb Mixing Ratio (100*(g/kg)/yr)



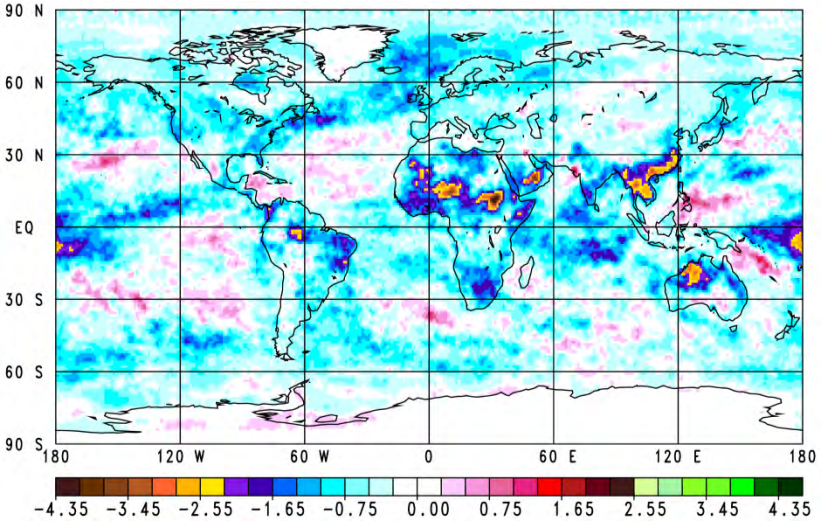
Global Mean= -0.325 STD= 0.455 Corr= 0.98

Cloud Fraction (%/yr)



Global Mean= 0.211 STD= 0.277 Corr= 0.88

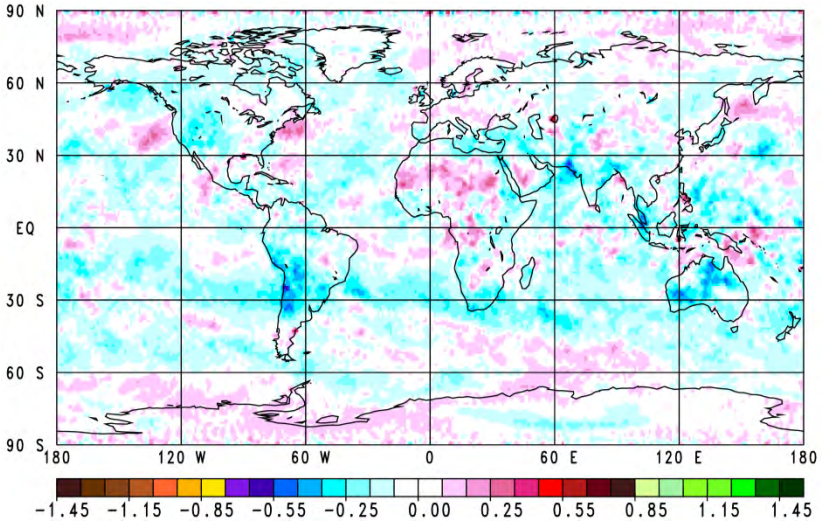
Total Precipitable Water (mm/yr)



Global Mean= -0.529 STD= 0.572 Corr= 0.97

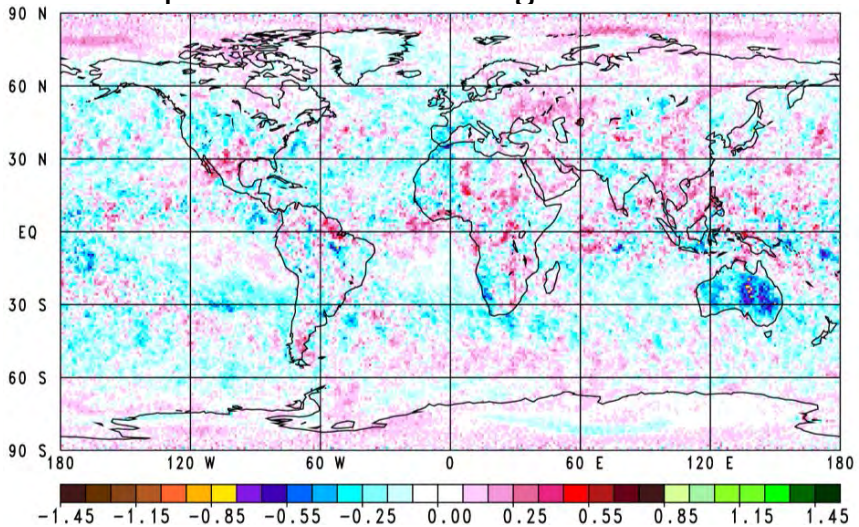
Trend Differences (W/m^2/yr)

Version-5 minus Version-6 OLR
12 Months



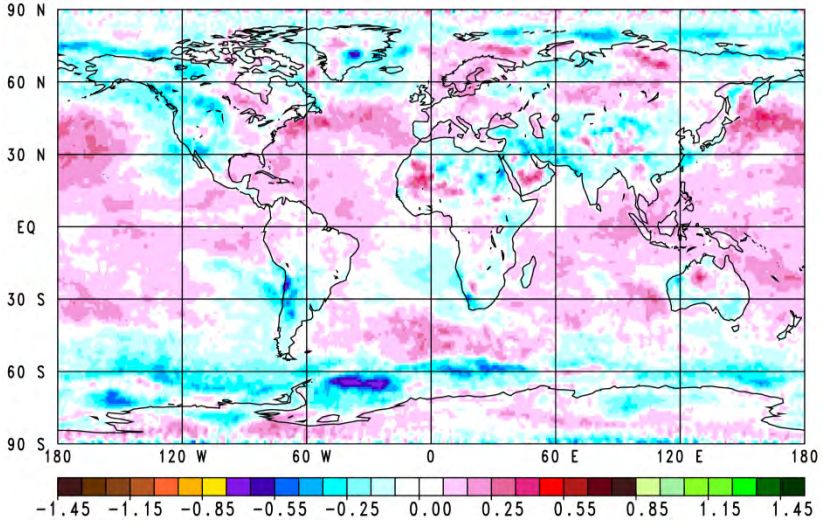
Global Mean= -0.066 STD= 0.11 Corr= 0.99

AIRS minus CERES OLR
September 2002 through June 2011



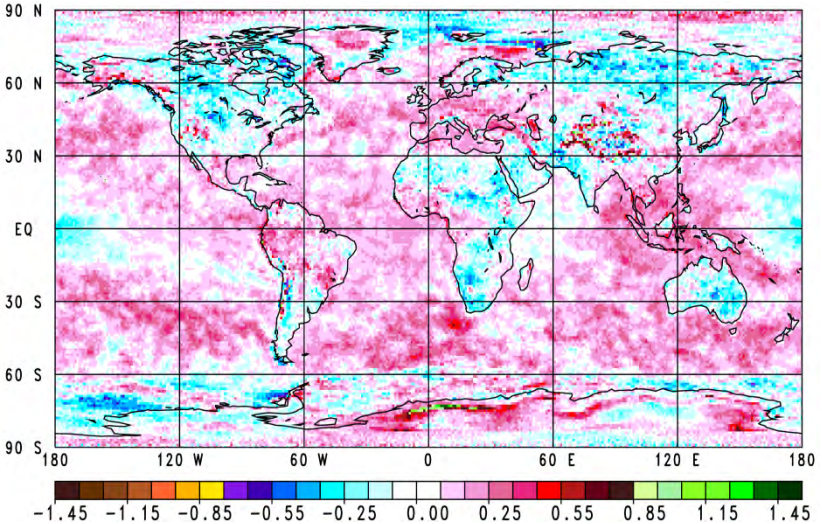
Global Mean= -0.035 STD= 0.15 Corr= 0.98

Version-5 minus Version-6 Clear Sky OLR
12 Months

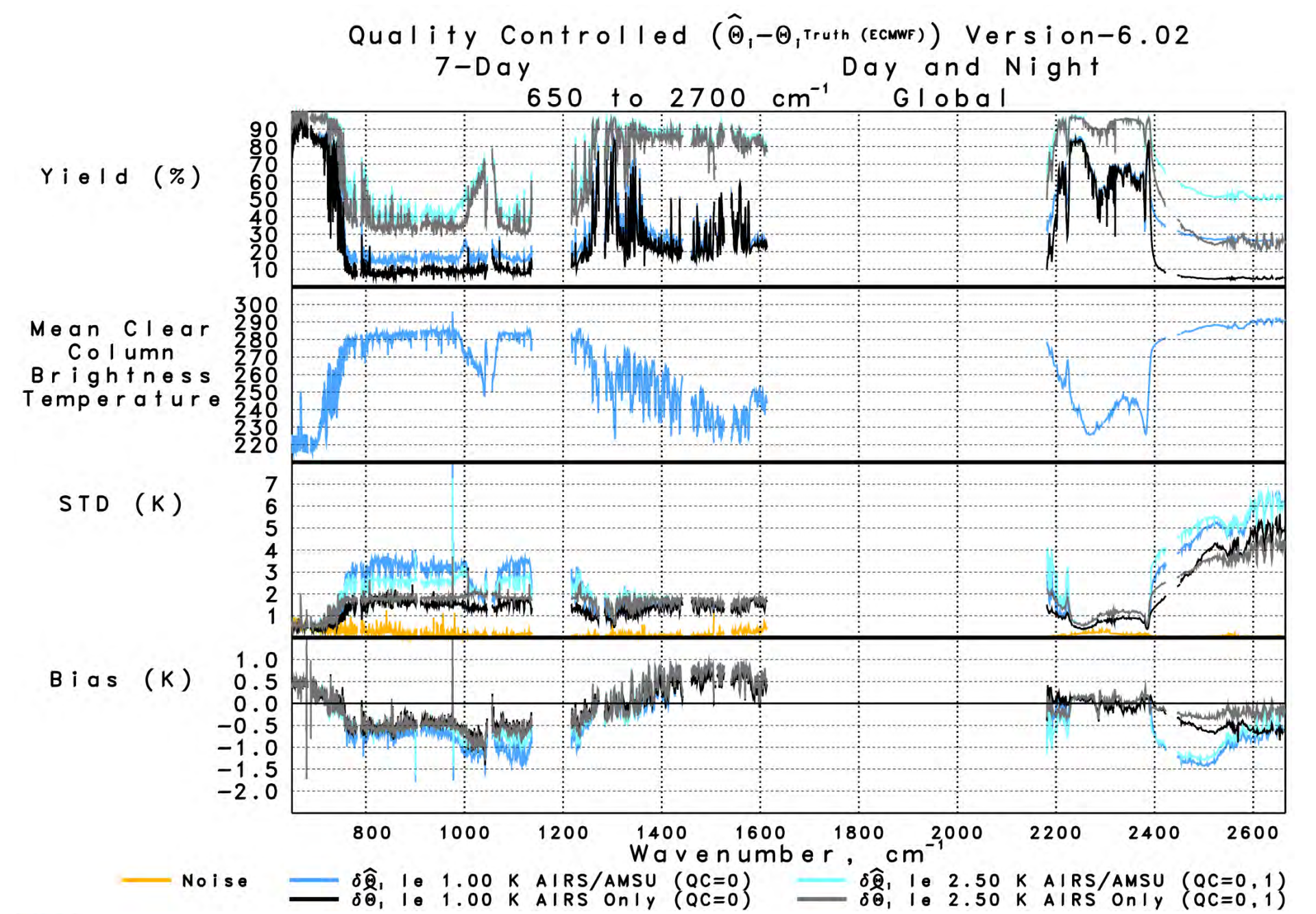


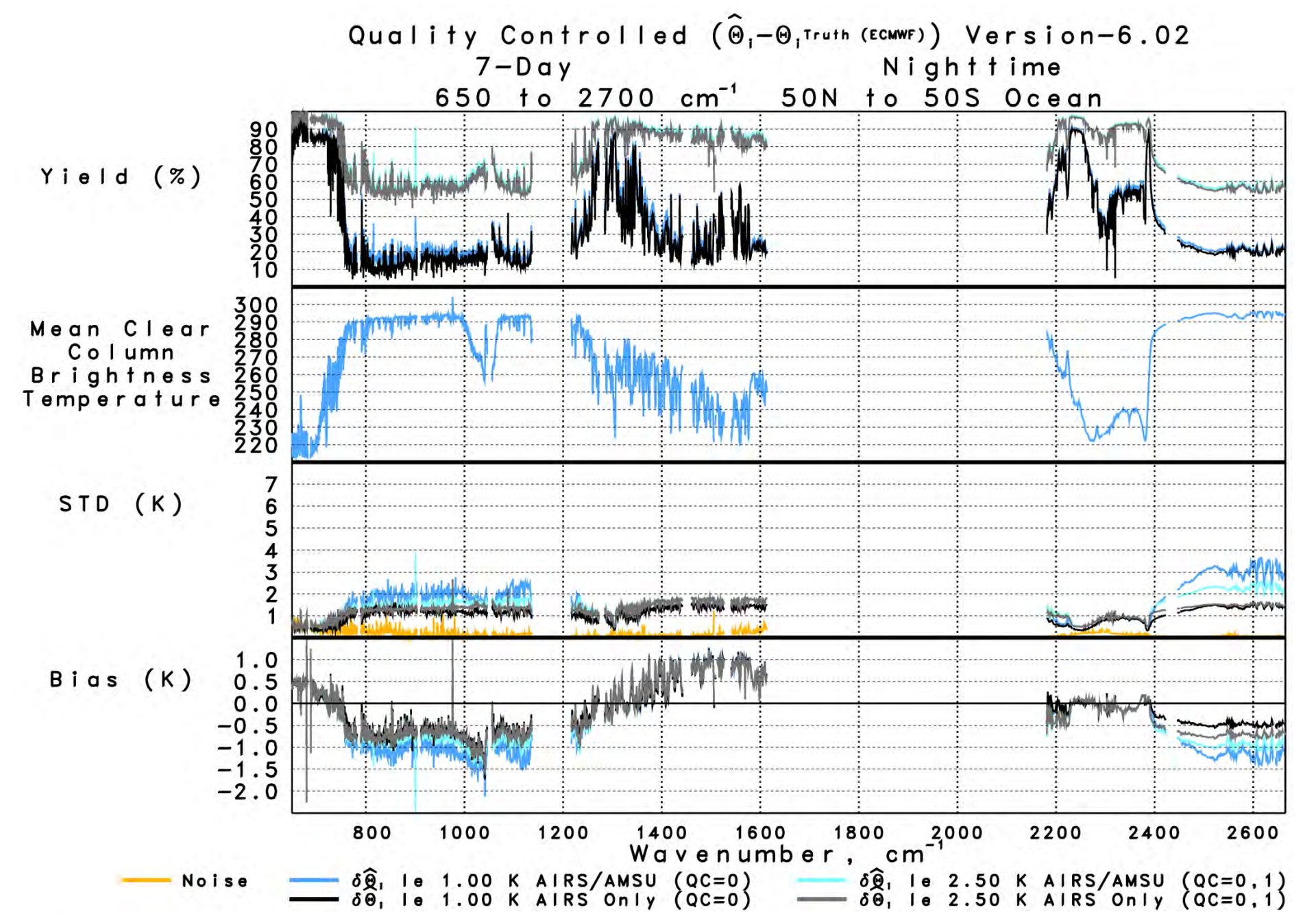
Global Mean= 0.014 STD= 0.12 Corr= 0.96

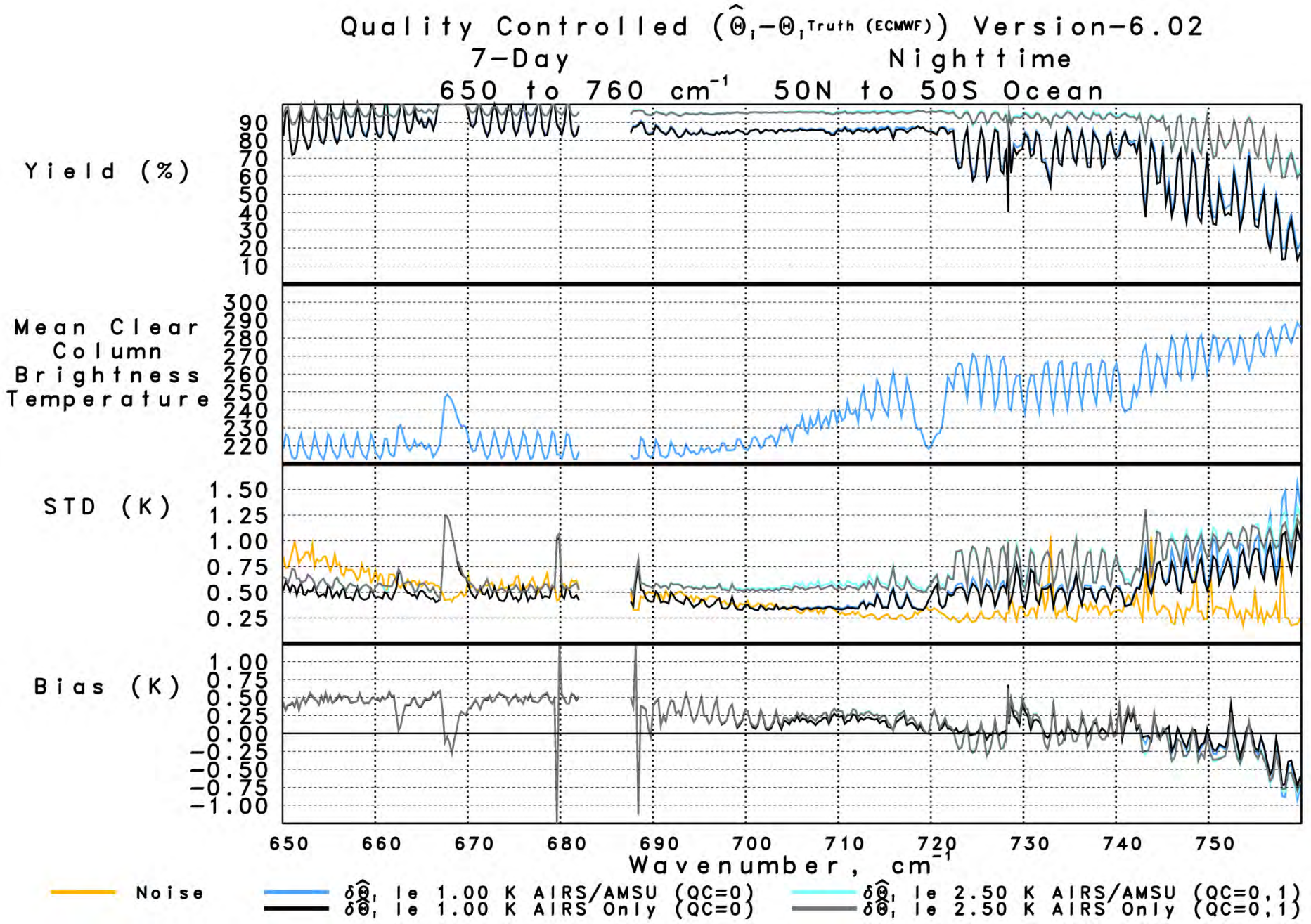
AIRS minus CERES Clear Sky OLR
September 2002 through June 2011



Global Mean= 0.067 STD= 0.16 Corr= 0.82


Quality Controlled ($\hat{\Theta}_1 - \Theta_{1\,Truth\ (ECMWF)}$) Version-6.02
7-Day
Day and Night
650 to 2700 cm^{-1}
Global
Yield (%)
90
80
70
60
50
40
30
20
10
Mean Clear Column Brightness Temperature
300
290
280
270
260
250
240
230
220
STD (K)
7
6
5
4
3
2
1
Bias (K)
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Wavenumber, cm^{-1}
Noise
$\delta\hat{\Theta}_1$, le 1.00 K AIRS/AMSU (QC=0)
$\delta\Theta_1$, le 1.00 K AIRS Only (QC=0)
$\delta\hat{\Theta}_1$, le 2.50 K AIRS/AMSU (QC=0,1)
$\delta\Theta_1$, le 2.50 K AIRS Only (QC=0,1)


Quality Controlled ($\hat{\Theta}_1$−$\Theta_1^{Truth\ (ECMWF)}$) Version−6.02
7−Day
Nighttime
650 to 2700 cm^{-1}
50N to 50S Ocean
Yield (%)
90
80
70
60
50
40
30
20
10
Mean Clear Column Brightness Temperature
300
290
280
270
260
250
240
230
220
STD (K)
7
6
5
4
3
2
1
Bias (K)
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Wavenumber, cm^{-1}
Noise
$\delta\hat{\Theta}_1$, le 1.00 K AIRS/AMSU (QC=0)
$\delta\Theta_1$, le 1.00 K AIRS Only (QC=0)
$\delta\hat{\Theta}_1$, le 2.50 K AIRS/AMSU (QC=0,1)
$\delta\Theta_1$, le 2.50 K AIRS Only (QC=0,1)


Quality Controlled ($\hat{\Theta}_1 - \Theta_{1\,Truth\ (ECMWF)}$) Version-6.02
7-Day
Nighttime
650 to 760 cm^{-1} 50N to 50S Ocean
Yield (%)
90
80
70
60
50
40
30
20
10
Mean Clear Column Brightness Temperature
300
290
280
270
260
250
240
230
220
STD (K)
1.50
1.25
1.00
0.75
0.50
0.25
Bias (K)
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
650
660
670
680
690
700
710
720
730
740
750
Wavenumber, cm^{-1}
Noise
$\delta\hat{\Theta}_1$, le 1.00 K AIRS/AMSU (QC=0)
$\delta\Theta_1$, le 1.00 K AIRS Only (QC=0)
$\delta\hat{\Theta}_1$, le 2.50 K AIRS/AMSU (QC=0,1)
$\delta\Theta_1$, le 2.50 K AIRS Only (QC=0,1)

Summary

All Version-6.02 products are significantly improved over Version-5

- Level-2, Level-3
- yields, RMS accuracy, biases, trends

Channel-by-channel QC for cloud cleared radiances work very well

- Was not a part of Version-5

We see no shortcomings in Version-6 products that must be changed before delivery

An analysis of trends from 12 months of Version-6, Version-6 AO should still be done

- We do not expect much difference from Version-5.9.12
- We expect that Version-6 AO will also perform well
- We will also look at trends of spectral OLR